(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : 0 451 426 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification : **02.11.94 Bulletin 94/44**

(51) Int. Cl.^{5} : **H04L 12/40**

(21) Application number : **90810294.0**

(22) Date of filing : **11.04.90**

(54) Multiple-access control for a communication system with order pad passing.

(43) Date of publication of application : **16.10.91 Bulletin 91/42**

(45) Publication of the grant of the patent : **02.11.94 Bulletin 94/44**

(84) Designated Contracting States : **DE FR GB**

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EP 0 451 426 B1

Description

FIELD OF INVENTION

Present invention is concerned with a multiple-access technique for a communication system based on a transmission bus to which several stations or nodes and headend means are connected, and in which for several separate and sequential operation cycles, an order pad is issued by the headend means and passed along the associated bus for insertion of access requests by the node stations. An accumulated count or request length is stored in the headend unit together with the respective cycle number, and when the respective cycle ist started, the headend issues the required number of slots so that each node station can definitely use the number of slots it has requested for that cycle.

BACKGROUND

A system of the type described above was disclosed in EP-A-0 393 293, published on 24.10.90, entitled "Method and Apparatus for Cyclic Rreservation Multiple Access in Communication Systems". In a system of that kind, slots of a particular operation cycle are reserved for nodes which have requested them. However, the reservation is by quantity (number of slots) and the slots are not individually assigned to a node.

Each slot, in such a system, is used only for a portion of its passage along the bus, i.e. between the origin node and the destination node of the data which the slot carries in that cycle. In many typical traffic situations, traffic is rather localized and slots will be used only for carrying data between neighbourhood nodes.

It would be possible to set each slot to "free" when it has reached the destination, to allow subsequent usage by other nodes. However, this would prevent an ordered access mechanism and in particular the guaranteed availability of consecutive time slots for a node, which is a definite advantage of the described system which uses a cyclic reservation technique based on order pad processing.

OBJECTS OF THE INVENTION

It would be desirable to enable additional usage (reuse) of time slots which have reached their destinations on the bus, without giving up the advantages of the cyclic reservation mechanism used in the known system.

Therefore, it is an object of present invention to enable, in a system using an order pad passing procedure for cyclic reservation multiple-acces, the reuse of time slots which would otherwise be utilized only during a portion of their passage along the bus.

In particular, it is an object of the invention to allow time slot reuse in such an order pad passing cyclic reservation system, without giving up the advantage of guaranteed availability of the time slots for a node in a consecutive sequence; i.e. all time slots reserved in a particular cycle for a node should be available, despite reuse, without interleaving slots carrying data from other nodes.

RESUME OF THE INVENTION

These objects are achieved by a multiple-access method for a communication system as defined in Claim 1.

LIST OF FIGURES

Fig.1 is a block diagram of a dual bus communication network in which the invention is used.

Fig.2 depicts the segmentation of a data frame which is to be transmitted, into segment payloads for insertion into time slots provided by the dual bus communication system.

Fig.3 shows the time slot format used.

Fig.4 illustrates a typical communication traffic situation on a dual-bus communication system in which a significant advantage can be gained by the invention.

Fig.5 illustrates the time slot history in the dual-bus system when the invention is not used (no slot reuse).

Fig.6 depicts the medium access control (MAC) commands to be used for the order pad passing reservation procedure.

Fig.7 shows schematically the local reservation queue of a node, with reuse flags according to the invention.

Fig.8 is a flow diagram of the order pad passing reservation procedure with slot reuse according to the invention.

Fig.9 is a diagram showing the time slot history for the traffic situation of Fig.4, in a system providing slot reuse according to the invention.

Fig.10 (10A and 10B) is a block diagram of the node apparatus implementing the invention for providing slot reuse in a dual-bus system with an order pad passing reservation procedure.

Abbreviations Used

Following is a list of abbreviations used in the description.

Global / Headend Unit

CYC-NUM	Cycle Number
REQ-LEN	Requested Length (= cumulated)
REQ-MAX	Requested Maximum
DST-MAX	Destination Maximum (= node label of furthest destination)

Local / Nodes

ORD-DST	Order destination = D(j) (= node label of destination to which node j wants to transmit)
ORD-LEN	Order Length = S(j) (= number of slots ordered by node j)
NOD-LBL	Node Label = j

General

ORD-PAD	Order Pad (Command)
STA-CMD	Start Command
REU-FLG	Reuse Flag (in local reservation queue)

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Environment

The environment or general system in which the present invention finds application is shown in Fig.1. It is a dual-bus communication system with a plurality of nodes or stations attached to each of the busses, and with two headend functions at the ends of the two busses. Each of the headend functions may be integrated with a node station as indicated in Fig.1 (e.g. headend HEAD-A with node 1). A similar system in which cyclic-reservation multiple access (CRMA) is provided by an order pad passing procedure, is desrcibed in EP-A- 0 393 293 (mentioned above already).

The system comprises an A-bus (11) and a B-bus (13) which serve as transmission medium for the one and the other direction. Two headend functions, HEAD-A (15) and HEAD-B (17) are provided. A plurality of node stations (19-1.... 19-N) are attached to both busses. Each headend issues fixed-length time slots on its associated bus for use by the nodes. The time slots are organized in sequential cycles (of variable length) as indicated in Fig.1. Every cycle is explicitly numbered modulo some maximum number.

To regulate access to the transmission medium, i.e. usage of the time slots for data transmission, an order pad passing procedure is used (as described in the above-mentioned European patent application). Each headend issues, on its associated bus, order pads (and other associated commands) which are transmitted at the leading ends of the time slots, as indicted by darker shaded bars in Fig.1. Each order pad is associated with a (future) transmission cycle; any node that wants to transmit data, requests the required number of slots (the "order length") by adding this quantity to a number in the order pad, the "requested length". It stores the requested number in a Local Reservation Queue, which is shown as box 21 in node N-1,together with the respective cycle number. The order pad, when arriving at the end of the bus, indicates by the accumulated requested length the total number of slots which are required for that cycle. The companion headend, which receives the order pad, returns it on its associated bus to the originating headend. There, the accumulated requested length is stored, together with the cycle number, in a Global Reservation Queue, which is shown in HEAD-A as box 23.

For each cycle, the headend unit issues a cycle start command (also transmitted along the bus in a time slot) containing the respective cycle number, and thereafter releases a number of slots as indicated in its Global Reservation Queue for this cycle. Each station along the bus, after recognizing the cycle start command, then

uses a number of consecutive free time slots for data transmission which corresponds to the order length number stored in its Local Reservation Queue with that cycle number.

In low traffic situations, e.g. when an order pad returns to the originating station without any reservations, the headend may issue time slots without a leading cycle start command, as is indicated in Fig.1 by the section "free use" between cycles 5 and 8 (i.e. order pads for cycles 6 and 7 contained no reservations when returning to the headend). During such a period, any station may use any free slot it sees on the bus, without prior reservation.

In Fig.2 there is shown the principle for segmenting data frames prior to transmission so that they can be accomodated in the fixed-length time slots propagating on the bus. Each frame (which may be of any length up to a given maximum) and which contains the necessary delimiters SS (start sequence) and ES (end sequence), is simply cut into equal-size segments (payloads) which fit into the fixed-length data segment fields of the time slots. A segment header (e.g. a one byte "type" field) is added to each segment payload for identifying the type of segment payload (e.g. FDDI, 802.2, HPPI data, or begin/middle/end/single segment of a frame) and inserted together with the segment payload into a passing free time slot. Due to the cyclic-reservation multiple access (CRMA) technique roughly described above, each station is guaranteed the availability of n consecutive free time slots in a cycle for which it requested n time slots. This is very important because it eliminates the need for extensive protocol information and consecutive numbering of the segment payloads. They arrive at their destination in consecutive time slots (and of course in the same order as they were transmitted).

As is also shown in Fig.2, each time slot, besides a segment payload and associated header (together representing a data channel), also includes a section for commands or signalling information (representing a signalling channel), and of course a slot delimiter. Where necessary, a slot is filled up by padding data when the last payload segment does not exactly fit the slot segment size.

Fig.3 shows the slot format in somewhat more detail. It is assumed here that each slot has a size of p+q bytes (e.g. 58 bytes as an example). The actual data segment for the data payload comprises q bytes (e.g. 53 bytes). The remaining p bytes (e.g. 5 bytes) are provided for system information. One byte represents the slot delimiter, the following bytes are representing an Access Control Field ACF (containing the commands or signalling information, to be explained later in more detail), and the last remaining byte is provided for the segment header (as shown in Fig.2). The first field (e.g. two bits) of each ACF contains Slot Control (SC) information. One of these bits may indicate whether the slot is a free-use slot not associated with a specific numbered cycle (cf. Fig.1); the other bit "B/F" indicates whether the slot's data segment is busy (occupied) or free.

The general formats of the Global Reservation Queue and the Local Reservation Queue are shown in the following Table I:

Table I. Global and Local Reservation Queues (without slot reuse)

Global Reservation Queue (for a certain priority class)			Local Reservation Queues (for a certain priority class)		
CYCLE NUMBER	REQUESTED LENGTH		CYCLE NUMBER	ORDER LENGTH	PENDING / CONFIRMED

The Global Reservation Queue stored in the headend contains in each entry, as already mentioned above, a cycle number and the associated requested length (i.e. the accumulated number of time slots requested by all the nodes for that cycle).

The Local Reservation Queue contains in each entry a cycle number and an associated order length, i.e. the number of slots requested by the respective station for the cycle indicated. An extra bit in each entry indicates the status of the entry as being pending or confirmed. Initially, the bit is set to zero, indicating pending state. The headend station, depending on the traffic situation, can accept the reservations for a particular cycle

by issuing a "Confirm" command with the respective cycle number, or by issuing a "reject" command which cancels all pending reservations of cycles which were not yet confirmed. Each node, when receiving a confirm command, converts the status of the entry for the respective cycle number to "confirmed" by setting the bit to one. Only then, the reservation is valid. However, each station receiving a reject command cancels all reservations which are still in the "pending" status (these reservations must be repeated later). Details of these procedures are also described in the aforementioned European patent application.

It should further be mentioned that several priorities can be provided (e.g. four different priorities). Priorities are implemented by replicating the reservation queues both at the headends and nodes. Thus, for each priority there is a separate reservation mechanism, and separate Local and Global Reservation Queues are maintained. All the commands are then also associated with one of the priorities. Access commands and cycles with higher priority preempt lower priority access commands and cycles. However, to simplify the description, all steps and procedures are only explained for one priority in the following description.

Existing Problem

In the multiple-access procedure described so far, each slot issued by the headend is only used once, i.e. it is utilized only during a portion (fraction) of its propagation along the respective bus.

This is inefficient and a significant improvement is possible in the following typical situation in which data traffic is concentrated in neighborhood (local) sections of the network, as is shown in Fig.4.

The situation is illustrated in the following example where the nodes 1, 2, and 3 want to transmit 6, 2 and 5 slots to node 3 and to the server-1 (SER-1, i.e. node 4), respectively. Node 4 requests 7 slots destined to node 5, and nodes 5, 6, and 7 are requesting 4, 7, and 9 slots, all destined to the server-2 (SER-2, i.e. node 8).

The required total number of slots (global requested length) for the respective cycle, as can be seen from the order pad history table below, is 40. Thus, the headend must issue 40 slots which, however, are actually utilized only for a fraction of their existence, as is illustrated in Fig.5 and the following Table II.

Table II. Processing of the ORDER PAD command at the nodes in CRMA			
Requesting node's data			ORDER PAD when leaving node
j = NODE LABEL	D(j) = ORDER DESTINATION	S(j) = ORDER LENGTH	REQUESTED LENGTH
1	3	6	0+6=6
2	4	2	6+2=8
3	4	5	8+5=13
4	5	7	13+7=20
5	8	4	20+4=24
6	8	7	24+7=31
7	8	9	31+9=40

The invention provides a major improvement in this situation.

Improved Access Procedure (Reservation Technique) with Slot Reuse

The proposed technique for cyclic-reservation multiple access (CRMA) with slot reuse allows for significant increase in network capacity and reduced access delay under high load without giving up the basic CRMA advantages. This is achieved by introducing more intelligence in the order pad passing process, making use of the fact that slots which have reached their destinations at a certain node could be overwritten i.e., reused by other (downstream) nodes. For that purpose each node is allowed to reset the "requested length" parameter of the order pad to zero, whenever it is guaranteed that all requested slots (i.e. the segment payloads they contain) will have reached their destination upon arrival at this node. Hence, the reservation process can restart as if the order pad was issued by a headend, leading to an overall cycle length which is much shorter than in basic CRMA, i.e. the capacity increases and the access delay is reduced.

In order to decide whether the slots will have reached their destinations, "node labels" which indicate the node positions along the bus must be introduced and some information about the destinations of the requested slots must be included in the order pad command. Furthermore, an indication about the reuse possibility in the data transmission process must be added to the Local Reservation Queues (to be explained later in more detail in connection with Fig .7). The Global Reservation Queue is not changed.

The order pad command for CRMA with slot reuse (CRMA/SR) contains now three parameters which are processed at the nodes. The "Requested Length" (REQ-LEN) parameter is similar to the same parameter in basic CRMA, except that it contains the accumulated number of ordered slots since its last reset to zero. The "Requested Maximum" (REQ-MAX) parameter saves the absolute maximum of the Requested Length within that cycle. It is initially set to zero and updated by each node whenever the accumulated Requested Length is larger than the current value of Requested Maximum. The "Destination Maximum" (DST-MAX) holds the node label of the most downstream destination of the already requested slots.

The order pad command issued by the headend will thus have the following contents (Table III):

Table III. Order Pad Command Contents			
Field	Parameter	Size (Bits), e.g.:	New
Command Code		6	
Cycle Number	(Number of Cycle)	8	-
Cycle Priority	(Priority)	2	-
Requested Length	(Number of Slots)	16	-
Requested Maximum	(Number of Slots)	16	+
Destination Maximum	(Node Label)	8	+

The order pad information is carried in the signalling channel fields of consecutive slots. An example of the possible Access Control Fields (ACF) for typical commands, in particular those for the order pad with slot reuse capability, is shown in Fig.6. Each ACF field comprises three bytes. The first byte includes two bits for Slot Control (SC) (= free-use bit and busy/free bit); four bits for a command code word; and two bits (PRI) for the priority. The other two bytes of the ACF field contain the parameter(s) of the respective command. While the commands for confirm, cycle start, and reject are not different for systems providing slot reuse and those providing no slot reuse, the three order pad commands (partial commands) have a modified structure to accomodate the additional fields for the Requested Maximum and the Destination Maximum, respectively (besides the fields for command code, cycle priority, cycle number, and Requested Length). In comparison to the slot structure shown in Fig.3, described in the aforementioned European patent application, which provided two bytes for the ACF, that field now has a size of three bytes. (However, in order to keep exactly the same

slot structure, information of the commands A, B, C could be sent in 6 instead of just 3 slots.) Fig.6 shows seven different commands; some commands such as RECOVERY or NOOP are not shown here because they are not relevant for the invention. Due to the four-bit command code words, a total of 16 different commands is possible.

The Local Reservation Queues are also modified and contain, in each entry (and for each priority separately), besides the cycle number, requested length, and a pending/confirmed status indication, also a "reuse flag" (REU-FLG), as is illustrated in Fig.7. The Global Reservation Queue in the headend needs not to be different because the slot reuse mechanism is transparent (not visible) to the headend; it merely takes the Requested Maximum as total (accumulated) requested length instead of the Requested Length per se.

Operation of the new improved reservation and access procedure is illustrated in the flow diagram of Fig.8.

A node j which wants to transmit S(j) data units (segment payloads) (where S(j) = Order Length) to an Order Destination D(j) makes a reservation for S(j) slots by processing the incoming order pad command as illustrated in Fig.8. First, the Destination Maximum (DST-MAX), which contains the most downstream destination of all upstream requests, is compared with the own node label j. If the Destination Maximum is smaller or equal than the node label j, slot reuse is possible, i.e. all requested slots of the upstream nodes will have reached their destinations upon arrival at this node. The node sets in the Local Reservation Queue the "Reuse Flag" REU-FLG(x) for that cycle x (which will cause later, after actual start of the respective cycle; the use of the first data slots after the cycle start command for transmitting the S(j) data units (segment payloads) of that node, and a resetting of all busy/free bits of the remaining slots to "free"). The Destination Maximum is overwritten with the label of the destination where the own slots will be destined to, i.e. with D(j) (= ORD-DST). If a node has no request, it either does not process the command or it uses Order Length = 0 and Order Destination = 0. Finally, node j can overwrite the Requested Length parameter of the order pad with its own Order Length.

If the Destination Maximum is greater than the node label j, slot reuse is not possible. Hence, the 'non-reusing node' sets the Reuse Flag in the Local Reservation Queue to 'false'. The order pad parameter Destination Maximum is only overwritten with D(j) (= Order Destination) if the latter points to a destination further downstream, i.e. if the current Destination Maximum is smaller than D(j). As in CRMA, the number of requested slots S(j) (= ORD-LEN) is added to the order pad parameter Requested Length, i.e. to the accumulated requests of the upstream nodes.

The Requested Maximum reflects the maximum number of requested slots which ever occurred during the passing of this specific order pad, in order to guarantee that the generated cycle length will be sufficient for all transmissions.

The resulting reservation and data transmission process, for the traffic situation that was shown in Fig.4, is illustrated in the following Table IV and in Fig.9.

Table IV. Processing of the ORDER PAD command at the nodes in CRMA/SR						
Requesting node's data			ORDER PAD when leaving node			REUSE FLAG
j = NOD-LBL	D(j) = ORD-DST	S(j) = ORD-LNG	DST-MAX	REQ-LNG	REQ-MAX	REU-FLG(x)
1	3	6	3	0+6=6	6	true (1)
2	4	2	4	6+2=8	8	false (0)
3	4	5	4	8+5=13	13	false (0)
4	5	7	5	7	13	true (1)
5	8	4	8	4	13	true (1)
6	8	7	8	4+7=11	13	false (0)
7	8	9	8	11+9=20	20	false (0)

As can be seen, whenever all slots have reached their initial destination (which is the case at node 4 in this example), they can be reused, i.e. all the slots that had been issued by the headend are then available for reuse. The same then happens when all slots have reached their second destination (which is the case at node 5 in the present example), and so on. Thus, each slot can be used several times during its passage along its bus.

The total cycle length, in this example, is reduced by a factor of two because only 20 slots need to be issued by the headend instead of 40 slots.

Implementation of Control Apparatus for Slot Reuse

Fig.10 is a block diagram of apparatus implementing the control functions for slot reuse in an order pad passing system. This control apparatus is provided in each of the nodes of the dual bus system.

In the transmission medium 25, there is provided ACF extraction means 27 and, connected to it, ACF processing means 29 which receives and tests the data contained in the Access Control Field (ACF) of each slot passing on the transmission medium. ACF change/insertion means 31 allows to change the information contained in a passing ACF, or to insert new information into specific fields of each passing slot ACF.

Also shown in Fig.10 are the storage for the Local Reservation Queue 33 (which will not be described in detail) and a queue storage accessing control section 35 connected to it. The Local Reservation Queue is connected to other portions of the node (which are not shown here) by lines 37. A further section contains the transmit requests of the respective node, in particular the desired number of slots and the respective destination, is shown as block 39. It is connected to the queue storage accessing control 35 by lines 41, and to other portions of the node (not shown here) by lines 43. It provides on output lines 45 the desired number of slots as Order Length ORD-LEN S(j), and on lines 47 the node label of the destination as Order Destination ORD-DST D(j).

When one of the order pad commands (A/B/C) is detected, this is indicated by activation of a control signal on one of lines 49 (A/B/C). The local node id (NOD-LBL) j is stored in a register 51 and available on lines 53. The Destination Maximum DST-MAX of the arriving ACF is provided on lines 55. Both values are compared in comparing means 57. If DST-MAX is greater than ORD-DST, a control signal is activated on line 59, indicating that no reuse is possible. If DST-MAX is less than or equal to ORD-DST, then a control signal is activated on line 61 indicating that from this node on, slot reuse is possible.

No Slot Reuse:

If no slot reuse is possible, the control signal on line 59 causes resetting of the Reuse Flag in the entry of the Local Reservation Queue for the respective cycle number. The cycle number is provided on lines 63 to queue storage accessing control section 35.

The Destination Maximum DST-MAX appearing on lines 55, and the order Destination ORD-DST appearing on lines 47, are compared in comparison means 65. If the (locally requested) ORD-DST is greater then the arriving DST-MAX, then a control signal is activated on the output of comparison means 65 and passed through AND gate 67, control line 69 and OR gate 71 to gating means 73 which passes the ORD-DST from lines 47 to a DST-MAX line 75 for insertion into the respective field of the passing slot ACF. If the arriving DST-MAX value was greater then the local ORD-DST, then the DST-MAX in the passing slot ACF is not changed.

Then, the Requested Length which is contained in the next arriving slot ACF appears on lines 77 (REQ-LEN (IN)). It is augmented by the Order Length ORD-LEN S(j) (appearing on lines 45) in adding means 79 and the new augmented Requested Length is furnished via lines 81 and OR gates 83 to lines 85 (REQ-LEN (OUT)) for insertion into the respective field of the passing slot ACF.

Slot Reuse:

If slot reuse is possible from the repective node on, the control signal on line 61 causes the Reuse Flag (REU-FLG) in the entry of the Local Reservation Queue for the respective cycle to be set.

The locally desired Order Destination (ORD-DST) D(j) appearing on lines 47 is gated via gating means 73 to DST-MAX output lines 75 for insertion into the DST-MAX field of the passing slot ACF (the existing value in this field is overwritten). A control signal is furnished to gating means 73 through OR gate 71 from line 61.

Then, the Order Length ORD-LEN S(j) appearing on lines 45 is gated, by gating means 87, through OR gates 83 to the REQ-LEN (OUT) lines 85 to cause insertion of the locally requested Order Length into the REQ-LEN field of the next slot ACF. The existing value is overwritten (it was saved already by a previous node into the field REQ-MAX).

Finally, for both cases (no slot reuse and slot reuse), the Requested Maximum REQ-MAX of the slot ACF of the third arriving slot comprising an order pad command, appearing on lines 89, is compared in comparing means 91 to the requested length REQ-LEN appearing on lines 85 which was inserted into the ACF of the previous slot. If the Requested Length REQ-LNG is greater than the existing REQ-MAX, the latter is overwritten by the former, caused by a control signal on line 93. Otherwise, the REQ-MAX value in the passing slot ACF is not changed.

Start of Cycle with Slot Reuse:

For starting the slot reuse procedure in a node where the reuse flag REU-FLG was previously set for a specific cycle, the following is provided in the node control circuitry:

When a cycle start command is detected in a slot ACF, a respective signal will be activated on line 95. This causes interrogation of the entry for the respective cycle in the Local Reservation Queue, and if the Reuse Flag is set for that cycle, a respective signal is activated on line 97. This causes the setting of a Reuse Latch 99. Its output signal on line 101, the activated, will cause the node to insert its n payload segments for that cycle into the next n passing slots. The control signal on line 101 further causes the setting of the free/busy bit in all passing slots to "free", until the next cycle start control signal appears which will cause resetting of the Reuse Latch 99. Thus, the respective node will release only free slots (except for the first n slots which it uses for itself) within the current cycle for use by the following nodes downstream.

No further details of the node control circuitry are shown here because they are not relevant for the present invention which is concerned with slot reuse, and because they are described already in the aforementioned European patent application.

Assignment of Node Labels

Labels are required in order to decide during the order pad passing process whether requested slots will have reached their destination when they pass at a certain node. The headend assigns the labels to the nodes via a "label" command which contains a Node Number (NOD-NUM) parameter. The Node Number is initially set to zero. Each active node increments the Node Number by one, uses the result as its label, and passes the command with the incremented parameter to the next node. Hence, the labels are assigned to the nodes such that they correspond to the position of the active nodes down the bus, i.e. the headend gets label "1"

and the last node on the bus gets the highest label number. The labels on the A-bus and B-bus are different. The sum of a node's A-Bus label and B-Bus label is equal to the total number of active nodes plus 1 (if the node labels start with 1). Use of the same labels for both buses is possible, but would require slightly different reservation algorithms for the two buses. The assignment of the various types of addresses, e.g. IEEE 802 addresses, to the labels is done via higher layer protocols.

Label Assignment Procedure Implementation:

Fig.10 also shows the means necessary in each node for implementing the node label assignment procedure. When a label command is received, the respective indicator signal on line 103 is activated. The current node number (NOD-NUM) of the received label command appears on lines 105. It should represent the node label of the previous node upstream the transmission medium. In adding means 107, this node number increased by one unit, and furnished on lines 109 for storing it in the local node label register 51 (thereafter appearing as node label j on its output), and for reinserting the new (increased) node number into the ACF field containing the label command, which further propagates down the transmission medium. When the label command reaches the end of the respective bus, all nodes will have node labels in ascending order.

Claims

1. A method of multiple-access control in a communication system comprising nodes attached to a transmission bus, in which system time slots are released in numbered cycles and an order pad is passed previously for each numbered cycle, containing a request count (REQ-LEN) which is increased by any node for reserving time slots, said method comprising the following steps, for reducing the number of time slots which have to be released:
   - carrying a furthest destination identification (DST-MAX) in each said order pad, which is updated by each node reserving time slots for data transmission to a selected destination node;
   - determining, from said furthest destination identification, sections of the transmission bus, each between two of said nodes, beyond which no data have to be transmitted in time slots of the respective cycle;
   - restarting said request count for each such section, and keeping the maximum value of the request count which occurred for any of said sections, as requested maximum (REQ-MAX) for the respective cycle;
   - releasing, for each cycle, a number of time slots corresponding to the requested maximum for that cycle; and
   - reusing, during each cycle, all time slots which pass a node located between any two of said sections which were determined for that cycle.

2. Method in accordance with claim 1, comprising the following further steps:
   - assigning identifying node labels (NOD-LBL) to all nodes in ascending order;
   - providing in each said order pad, besides a cycle number (CYC-NUM) and a field for said request count (REQ-LEN), a field for a furthest destination node label (DST-MAX), and a field for a requested maximum (REQ-MAX);
   - in each node which wants to reserve time slots for data transmission:

     (a) if the furthest destination node label (DST-MAX) in a received order pad is less than or equal to the own local node label, setting a local restart indication (REU-FLG), and restarting the request count (REQ-LEN) in said order pad;

     (b) updating, in a received order pad, the request count (REQ-LEN) by adding the locally required number of time slots (ORD-LEN), and updating said furthest destination node label by inserting the selected destination node label (ORD-DST) for the local data to be transmitted if the latter is greater than the furthest destination node label received in the order pad; and

     (c) transferring the resulting request count (REQ-LEN) into the field for the requested maximum (REQ-MAX) if the contents of the latter is smaller than the resulting request count.

3. Multiple-access control method for a communication system comprising nodes attached to a transmission bus and headend means for generating time slots and order pads for numbered cycles; each said order pad comprising a cycle number (CYC-NUM), and a request count (REQ-LEN) which each node can amend by a requested time slot number (ORD-LEN); each node using after start of the respective operation cycle

the requested number of free time slots; and each node being identified by a label (NOD-LBL) indicating its position; said method comprising the following steps:

providing in each said order pad, fields for a furthest destination node label (DST-MAX) and for a requested maximum (REQ-MAX), the contents of said fields being initially zero;

in each node intending to request time slots for transmitting local data to a selected destination:

(1) comparing said furthest destination node label (DST-MAX) with the own node label (NOD-LBL); and either

(a) if the furthest destination node label is equal to said own node label or identifies an upstream node:

- replacing the furthest destination node label (DST-MAX) by the selected destination node's label (ORD-DST);
- replacing the current request count (REQ-LEN) by the requested time slot number (ORD-LEN);
- storing a local restart indication (REU-FLG) for the respective operation cycle in the requesting node; or

(b) if the furthest destination node label identifies a downstream node:

- replacing the furthest destination node label (DST-MAX) by the selected destination node's label (ORD-DST) if the latter is greater;
- amending the current request count (REQ-LEN) by the requested time slot number (ORD-LEN); and

(2) replacing the requested maximum (REQ-MAX) by the resulting request count (REQ-LEN) if the latter is greater.

4. Method in accordance with claim 3, characterized in that each order pad is returned to its originating headend means, and that the value of the requested maximum (REQ-MAX) contained in the returning order pad, is stored together with the respective operation cycle number (CYC-NUM) in an entry of a global reservation queue maintained in said headend means.

5. Method in accordance with claim 2 or 3, characterized in that said local restart indication (REU-FLG) is stored, together with a respective cycle number (CYC-NUM) and the number of the requested time slots (ORD-LEN), in an entry of a local reservation queue maintained in each node.

6. Method in accordance with claim 2 or 3, for use in a system where each time slot comprises a busy/free indication which is set to busy when a node enters data into the slot, and in which each operation cycle is started by a numbered cycle start command, characterized in that a node containing a local restart indication (REU-FLG) for any specific cycle, after detecting the cycle start command for that cycle uses the first slots following the cycle start command for transmitting its local data, and then resets the busy/free indication in all following time slots to free until it detects the next cycle start command.

7. Method in accordance with claim 2 or 3, for use in a system in which each said order pad is distributed over the control fields of plural consecutive time slots, characterized in that the field for said furthest destination node label (DST-MAX) is contained in the first one of said control fields.

8. Method in accordance with claim 2 or 3, characterized in that for assigning node labels in ascending order to said nodes, a label command is issued, containing a node number (NOD-NUM) initially being zero; that each node receiving the label command increases the node number (NOD-NUM) by one unit and then stores the new value of the node number as its own node label (NOD-LBL) and transmits the label command to the next node.

9. Apparatus for allowing multiple use of time slots in a communication system comprising a unidirectional transmission medium (11; Fig.1), several nodes (19-1 ... 19-N) connected to it, and a headend means (15) for generating transmission time slots and control information passing on said transmission medium; an order pad being passed for each of plural numbered operation cycles, comprising a request count (REQ-LEN) which each node can amend by a requested time slot number (ORD-LEN); each node using after start of the respective operation cycle the requested number of free time slots; and each node being identified by a label (NOD-LBL) indicating its position; said apparatus comprising:

in said headend means

- means for generating order pads (Fig.6; A, B, C) including, besides a cycle number (CYC-NUM) and a field for said request count (REQ-LEN), further fields for a furthest destination node label (DST-

MAX) and for a requested maximum (REQ-MAX), respectively; and

in each said node,

- means (51; Fig.10) for storing a local node label (NOD-LBL);
- means (39) for storing the label (ORD-DST) of a selected destination node to which local data are to be transmitted;
- means (57) for comparing the furthest destination node label in a received order pad with the local node label;
- means (33, 35, 61) for storing the cycle number together with a reuse flag (REU-FLG), if the furthest destination node label is less than or equal to the local node label, and means (31, 47, 73, 75) for inserting the selected destination node's label into the furthest destination node label (DST-MAX) field of the order pad; and
- means (31, 95, 97, 99, 101) for making available, after start of a respective operation cycle for which the node has stored a reuse flag, all time slots of that respective operation cycle for use by the respective node or by other nodes further downstream.

10. Apparatus in accordance with claim 9, characterized in that each node further comprises:
- means (91) for comparing the requested maximum (REQ-MAX) in a received order pad with the current request count (REQ-LEN); and
- means (31, 85, 93) for replacing the requested maximum by the current request count if the latter is greater.

11. Apparatus in accordance with claim 9, characterized in that each node further comprises:
- means (45) for storing a requested number of slots (ORD-LEN);
- means (45, 61, 83, 85, 87) for replacing the current request count (REQ-LEN) in a received order pad by the requested number of slots (ORD-LEN) if the furthest destination node label (DST-MAX) is less than or equal to the local node label (NOD-LBL), but to add the requested number of slots to the current request count if the furthest destination node label is greater than the local node label.

Patentansprüche

1. Ein Verfahren für die Mehrfachzugriffssteuerung in einem Kommunikationssystem mit Knoten, die mit einem Übermittlungsbus verbunden sind, wobei in diesem System Zeitschlitze in numerierten Zyklen freigegeben und ein Reservierungsblock zuvor für jeden numerierten Zyklus übermittelt wird, der eine Anforderungszählung (REQ-LEN) enthält, die von jedem Knoten für die Reservierung von Zeitschlitzen erhöht wird, und wobei das Verfahren die folgenden Schritte zur Reduzierung der Anzahl von Zeitschlitzen umfaßt, die freigegeben werden müssen:
- der Transport einer weitesten Zielidentifizierung (DST-MAX) in jedem Reservierungsblock, die von jedem Knoten aktualisiert wird, der Zeitschlitze für die Datenübertragung zu einem ausgewählten Zielknoten reserviert;
- die Festlegung von Teilen des Übertragungsbusses auf der Grundlage der weitesten Zielidentifizierung, wobei die Teile jeweils zwischen zwei der Knoten sind, nach denen keine Daten mehr in Zeitschlitzen des entsprechenden Zyklus übermittelt werden müssen;
- den erneuten Start der Anforderungszählung für jeden Teil und die Beibehaltung des Maximalwertes der Anforderungszählung von jedem Teil als angefordertes Maximum (REQ-MAX) für den entsprechenden Zyklus;
- die Freigabe einer Anzahl von Zeitschlitzen für jeden Zyklus, die dem angeforderten Maximum für diesen Zyklus entsprechen; und
- die Wiederverwendung aller Zeitschlitze während jedes Zyklus, die einen Knoten durchlaufen, der zwischen zwei der für diesen Zyklus festgelegten Teile liegt.

2. Ein Verfahren nach Anspruch 1, das folgende weitere Schritte umfaßt:
- die Zuordnung von Identifizierungsknotenlabels (NOD-LBL) zu allen Knoten in steigender Reihenfolge;
- die Bereitstellung eines Feldes mit dem Knotenlabel für das weiteste Ziel (DST-MAX) sowie eines Feldes für ein angefordertes Maximum (REQ-MAX), neben einer Zyklusnummer (CYC-NUM) und eines Feldes für die Anforderungszählung (REQ-LEN) in jedem Reservierungsblock;
- in jedem Knoten, der Zeitschlitze für die Datenübermittlungs reservieren will:

(a) wenn das Knotenlabel für das weiteste Ziel (DST-MAX) in einem empfangenen Reservierungsblock kleiner oder gleich wie das eigene lokale Knotenlabel ist, erfolgt das Setzen einer lokalen Neustartanzeige (REU-FLG) und der erneute Start der Anforderungszählung (REQ-LEN) im Reservierungsblock;

(b) die Aktualisierung der Anforderungszählung (REQ-LEN) in einem empfangenen Reservierungsblock, indem die lokal erforderliche Anzahl von Zeitschlitzen (ORD-LEN) addiert wird, und das Knotenlabel für das weiteste Ziel aktualisiert wird, indem das Knotenlabel für das ausgewählte Ziel (ORD-DST) für die lokalen, zu übermittelnden Daten eingefügt wird, wenn letzteres größer als das im Reservierungsblock empfangene Knotenlabel für das weiteste Ziel ist; und

(c) die Übertragung der sich ergebenden Anforderungszählung (REQ-LEN) in das Feld für das angeforderte Maximum (REQ-MAX), wenn der Inhalt des letzteren kleiner als die sich ergebende Anforderungszählung ist.

3. Ein Mehrfachzugriffssteuerverfahren für ein Kommunikationssystem mit Knoten, die mit einem Übermittlungsbus und Kopfendemittel zur Erzeugung von Zeitschlitzen und Reservierungsblöcken für numerierte Zyklen verbunden sind; jeder Reservierungsblock umfaßt eine Zyklusnummer (CYC-NUM) und eine Anforderungszählung (REQ-LEN), die jeder Knoten durch eine angeforderte Zeitschlitznummer (ORD-LEN) ändern kann; jeder Knoten verwendet nach dem Start des entsprechenden Betriebszyklus die angeforderte Anzahl freier Zeitschlitze; und jeder Knoten wird von einem Label (NOD-LBL) identifiziert, das seine Lage anzeigt; wobei das Verfahren folgende Schritte umfaßt:
die Bereitstellung von Feldern für ein Knotenlabel für das weiteste Ziel (DST-MAX) und für ein angefordertes Maximum (REQ-MAX) in jedem Reseriverungsblock, wobei der Inhalt der Felder zu Beginn auf Null gesetzt ist;
in jedem Knoten, der Zeitschlitze für die Übertragung lokaler Daten zu einem ausgewählten Ziel anfordern will:

(1) der Vergleich des Knotenlabels für das weiteste Ziel (DST-MAX) mit dem eigenen Knotenlabel (NOD-LBL); und entweder

(a) wenn das Knotenlabel für das weiteste Ziel gleich wie das eigene Knotenlabel ist, das Identifizieren eines Upstream-Knotens;
- das Ersetzen des Knotenlabels für das weiteste Ziel (DST-MAX) durch das Knotenlabel für das ausgewählte Ziel (ORD-DST);
- das Ersetzen der aktuellen Anforderungszählung (REQ-LEN) durch die angeforderte Zeitschlitznummer (ORD-LEN);
- das Speichern einer lokalen Neustartanzeige (REU-FLG) für den entsprechenden Betriebszyklus im anfordernden Knoten; oder

(b) wenn das Knotenlabel für das weiteste Ziel einen Downstream-Knoten identifiziert:
- das Ersetzen des Knotenlabels für das weiteste Ziel (DST-MAX) durch das Knotenlabel für das ausgewählte Ziel (ORD-DST), wenn letzteres größer ist;
- das Ändern der aktuellen Anforderungszählung (REQ-LEN) durch die angeforderte Zeitschlitznummer (ORD-LEN); und

(2) das Ersetzen des angeforderten Maximums (REQ-MAX) durch die sich ergebende Anforderungszählung (REQ-LEN), wenn letzteres größer ist.

4. Ein Verfahren nach Anspruch 3, das dadurch gekennzeichnet ist, daß jeder Reservierungsblock zu seinem ursprünglichen Kopfendemittel zurückgesendet wird, und daß der Wert des angeforderten Maximums (REQ-MAX) im zurückgesendeten Reservierungsblock zusammen mit der entsprechenden Betriebszyklusnummer (CYC-NUM) in einem Eintrag einer globalen Reservierungsschlange im Kopfendemittel gespeichert wird.

5. Ein Verfahren nach Anspruch 2 oder 3, das dadurch gekennzeichnet ist, daß die lokale Neustartanzeige (REU-FLG) zusammen mit der entsprechenden Zyklusnummer (CYC-NUM) und der Anzahl der angeforderten Zeitschlitze (ORD-LEN) in einem Eintrag einer lokalen Reservierungsschlange in jedem Knoten gespeichert wird.

6. Ein Verfahren nach Anspruch 2 oder 3, das in einem System angewendet wird, wo jeder Zeitschlitz eine Belegt/Frei-Anzeige enthält, die auf belegt eingestellt wird, wenn ein Knoten Daten in den Schlitz schreibt, und in dem jeder Betriebszyklus von einem Startbefehl des numerierten Zyklus gestartet wird, wobei das

Verfahren dadurch gekennzeichnet ist, daß ein Knoten mit einer lokalen Neustartanzeige (REU-FLG) für jeden beliebigen Zyklus nach der Erfassung des Zyklusstartbefehls für diesen Zyklus die ersten Schlitze nach dem Zyklusstartbefehl zur Übermittlung seiner lokalen Daten verwendet, und dann die Belegt/Frei-Anzeige in allen folgenden Zeitschlitzen auf frei einstellt, bis der nächste Zyklusstartbefehl erfaßt wird.

7. Ein Verfahren nach Anspruch 2 oder 3, das in einem System angewendet wird, in dem jeder Reservierungsblock über die Steuerfelder zahlreicher aufeinanderfolgender Zeitschlitze verteilt ist; wobei das Verfahren dadurch gekennzeichnet ist, daß das Feld mit dem Knotenlabel für das weiteste Ziel (DST-MAX) im ersten der Steuerfelder enthalten ist.

8. Ein Verfahren nach Anspruch 2 oder 3, das dadurch gekennzeichnet ist, daß für die Zuordnung von Knotenlabels in steigender Reihenfolge zu den Knoten ein Labelbefehl ausgegeben wird, der die anfänglich auf Null gestellte Knotennummer (NOD-NUM) enthält; daß jeder Knoten, der den Labelbefehl empfängt, die Knotennummer (NOD-NUM) um eins erhöht und dann den neuen Wert der Knotennummer als sein eigenes Knotenlabel (NOD-LBL) speichert und den Labelbefehl zum nächsten Knoten übermittelt.

9. Eine Vorrichtung für die mehrfache Verwendung von Zeitschlitzen in einem Kommunikationssystem mit einem eindirektionalen Übermittlungsmedium (11; Fig. 1), mehreren daran angeschlossenen Knoten (19-1, ... 19-N) und einem Kopfendemittel (15) zur Erzeugung von Übermittlungszeitschlitzen und Steuerinformationsübermittlung auf dem Übermittlungsmedium; ein Reservierungsblock wird für jeden der zahlreichen numerierten Betriebszyklen übermittelt, der eine Anforderungszählung (REQ-LEN) enthält, die jeder Knoten durch eine angeforderte Zeitschlitznummer (ORD-LEN) ändern kann; jeder Knoten benutzt nach dem Start des entsprechenden Betriebszyklus die angeforderte Anzahl freier Zeitschlitze; und jeder Knoten wird durch ein Label (NOD-LBL) identifiziert, das seine Position anzeigt; wobei die Vorrichtung folgendes umfaßt:

im Kopfendemittel

- ein Mittel zur Erzeugung von Reservierungsblöcken (Fig. 6; A, B, C), die neben einer Zyklusnummer (CYC-NUM) und einem Feld für die Anforderungszählung (REQ-LEN) noch Felder mit dem Knotenlabel für das weiteste Ziel (DST-MAX) bzw. mit dem angeforderten Maximum (REQ-MAX) enthalten; und

in jedem Knoten

- ein Mittel (51; Fig. 10) zum Speichern eines lokalen Knotenlabels (NOD-LBL);
- ein Mittel (39) zum Speichern des Labels (ORD-DST) eines ausgewählten Zielknotens, zu dem die lokalen Daten übermittelt werden;
- ein Mittel (57) zum Vergleich des Knotenlabels für das weiteste Ziel in einem empfangenen Reservierungsblock mit dem lokalen Knotenlabel;
- Mittel (33, 35, 61) zum Speichern der Zyklusnummer zusammen mit dem Wiederverwendungs-Flag (REU-FLG), wenn das Knotenlabel für das weiteste Ziel kleiner oder gleich wie das lokale Knotenlabel ist, und Mittel (31, 47, 73, 75) zum Einfügen des Knotenlabels für das ausgewählte Ziel in das Feld mit dem Knotenlabel für das weiteste Ziel (DST-MAX) im Reservierungsblock; und
- Mittel (31, 95, 97, 99, 101) zur Bereitstellung - nach dem Start eines entsprechenden Betriebszyklus, für den der Knoten ein Wiederverwendungs-Flag reserviert hat, - aller Zeitschlitze des entsprechenden Betriebszyklus, die vom entsprechenden Knoten oder von anderen Knoten in Richtung downstream verwendet werden.

10. Eine Vorrichtung nach Anspruch 9, die dadurch gekennzeichnet ist, daß jeder Knoten weiterhin folgendes umfaßt:

- ein Mittel (91) zum Vergleich des angeforderten Maximums (REQ-MAX) in einem empfangenen Reservierungsblock mit der aktuellen Reservierungszählung (REQ-LEN); und
- Mittel (31, 85, 93) zum Ersetzen des angeforderten Maximums durch die aktuelle Anforderungszählung, wenn letztere größer ist.

11. Eine Vorrichtung nach Anspruch 9, die dadurch gekennzeichnet ist, daß jeder Knoten weiterhin umfaßt:

- ein Mittel (45) zum Speichern einer angeforderten Anzahl von Schlitzen (ORD-LEN);
- Mittel (45, 61, 83, 85, 87) zum Ersetzen der aktuellen Anforderungszählung (REQ-LEN) in einem empfangenen Reservierungsblock durch die angeforderte Anzahl von Schlitzen (ORD-LEN), wenn das Knotenlabel für das weiteste Ziel (DST-MAX) kleiner oder gleich wie das lokale Knotenlabel (NOD-LBL) ist, oder zum Addieren der angeforderten Anzahl von Schlitzen zu der aktuellen Anfor-

derungszählung, wenn das Knotenlabel für das weiteste Ziel größer als das lokale Knotenlabel ist.

Revendications

1. Procédé de gestion à accès multiple dans un système de communication comprenant des noeuds attachés à un bus de transmission, système dans lequel des tranches de temps sont émises en cycles numérotés et un bloc de commande est passé préalablement pour chaque cycle numéroté, contenant un compte de requêtes (REQ-LEN) qui est augmenté par tout noeud de réservation de tranches de temps, ledit procédé comprenant les étapes suivantes pour réduire le nombre de tranches de temps qui doivent être émises:
   - porter une identification de destination la plus éloignée (DST- MAX) dans chacun desdits blocs de commande qui est mis à jour par chaque noeud réservant des tranches de temps pour une transmission de données sur un noeud de destination sélectionnée;
   - déterminer, à partir de l'identification de destination la plus éloignée, des sections du bus de transmission, chacune entre deux desdits noeuds, au-delà desquelles aucune donnée ne doit être transmise dans des tranches de temps du cycle respectif;
   - redémarrer ledit compte de requêtes pour chaque section de ce type, et garder la valeur maximale du compte de requêtes qui est apparue pour l'une quelconque desdites sections, comme maximum requis (REQ-MAX) du cycle respectif;
   - émettre, pour chaque cycle, un nombre de tranches de temps correspondant au maximum requis pour ce cycle; et
   - ré-utiliser, durant chaque cycle, toutes les tranches de temps qui passent dans un noeud placé entre deux quelconques desdites sections qui ont été déterminées pour ce cycle.

2. Procédé selon la revendication 1, comprenant les autres étapes suivantes:
   - attribuer l'identification de labels de noeud (NOD-LBL) à tous les noeuds dans un ordre ascendant;
   - fournir dans chacun desdits blocs de commande, en plus d'un numéro de cycle (CYC-NUM) et d'un champ pour ledit compte de requêtes (REQ-LEN), un champ pour un label de noeud de destination la plus éloignée (DST-MAX), et un champ pour un maximum requis (REQ-MAX);
   - dans chaque noeud qui désire réserver des tranches de temps pour une transmission de données:
     (a) si le label de noeud de destination la plus éloignée (DST-MAX) dans un bloc de commande reçu est inférieur ou égal au propre label de noeud local, instaurer une indication de retard local (REU-FLG), et redémarrer le compte de requêtes (REQ-LEN) dans ledit bloc de commande;
     (b) mettre à jour, dans un bloc de commande reçu, le compte de requêtes (REQ-LEN) en ajoutant le nombre localement requis de tranches de temps (ORD-LEN), et mettre à jour ledit label de noeud de destination la plus éloignée en insérant le label de noeud de destination sélectionné (ORD-DST) des données locales à transmettre si ce dernier est supérieur au label de noeud de destination la plus éloignée reçu dans le bloc de commande; et
     (c) transférer le compte requis obtenu (REQ-LEN) dans le champ du maximum requis (REQ-MAX) si le contenu de ce dernier est inférieur à celui du compte de requêtes obtenu.

3. Procédé de gestion à accès multiple pour un système de communication comprenant des noeuds attachés à un bus de transmission et des moyens de tête de ligne pour engendrer des tranches de temps et des blocs de commande pour des cycles numérotés, chacun desdits blocs de commande comprenant un numéro de cycle (CYC-NUM), et un compte de requêtes (REQ-LEN) que chaque noeud peut modifier par un nombre de tranches de temps requis (ORD-LEN), chaque noeud utilisant, après le début du cycle opératoire respectif, le nombre requis de tranches de temps libres, et chaque noeud étant identifié par un label (NOD-LBL) indiquant sa position, ledit procédé comprenant les étapes suivantes:

   fournir, dans chacun desdits blocs de commande, des champs pour un label de noeud de destination la plus éloignée (DST-MAX) et pour un maximum requis (REQ-MAX), le contenu desdits champs étant initialement zéro;

   dans chaque noeud désirant demander des tranches de temps pour transmettre des données locales à une destination sélectionnée:

   (1) comparer ledit label de noeud de destination la plus éloignée (DST-MAX) au propre label de noeud (NOD-LBL); et soit

   (a) si le label de noeud de destination la plus éloignée est égal audit propre noeud de label ou identifie un noeud amont:

remplacer le label de noeud de destination la plus éloignée (DST-MAX) par le label du noeud de destination sélectionnée (ORD-DST);
- remplacer le compte de requêtes en cours (REQ-LEN) par le nombre de tranches de temps requises (ORD-LEN);
- emmagasiner une indication de redémarrage local (REU-FLG) pour le cycle opératoire respectif dans le noeud demandeur; soit

(b) si le label de noeud de destination la plus éloignée identifie un noeud aval:
- remplacer le label de noeud de destination la plus éloignée (DST-MAX) par le label du noeud de destination sélectionnée (ORD-DST) si ce dernier est supérieur;
- modifier le compte de requêtes en cours (REQ-LEN) par le nombre de tranches de temps requis (ORD-LEN); et

(2) remplacer le maximum requis (REQ-MAX) par le compte de requêtes obtenu (REQ-LEN) si ce dernier est supérieur.

4. Procédé selon la revendication 3, caractérisé en ce que chaque bloc de commande est retourné à son moyen de tête de ligne d'origine, et en ce que la valeur du maximum requis (REQ-MAX) contenue dans le bloc de commande retourné, est emmagasinée avec le numéro de cycle opératoire respectif (CYC-NUM) dans une entrée d'une file d'attente de réservations globale maintenue dans ledit moyen de tête de ligne.

5. Procédé selon les revendications 2 ou 3, caractérisé en ce que ladite indication de redémarrage locale (REU-FLG) est emmagasinée avec un numéro de cycle respectif (CYC-NUM) et le nombre de tranches de temps requises (ORD-LEN), dans une entrée d'une file d'attente de réservations locale maintenue dans chaque noeud.

6. Procédé selon les revendications 2 ou 3, pour une utilisation dans un système où chaque tranche de temps comprend une indication occupé/libre qui est instaurée à l'état occupé lorsqu'un noeud entre des données dans la tranche, et dans lequel chaque cycle opératoire est amorcé par une commande de départ de cycle numéroté, caractérisé en ce qu'un noeud contenant une indication de redémarrage local (REU-FLG) pour tout cycle spécifique, après avoir détecté la commande de départ de cycle pour ce cycle, utilise les premières tranches suivant la commande de départ de cycle pour transmettre ses données locales, et ensuite restaure l'indication occupé/libre dans toutes les tranches de temps suivantes à l'état libre jusqu'à ce qu'il détecte la commande de départ de cycle suivante.

7. Procédé selon les revendications 2 ou 3, pour une utilisation dans un système dans lequel chacun desdits blocs de commande est réparti sur les champs de contrôle de plusieurs tranches de temps consécutives, caractérisé en ce que le champ dudit label de noeud de destination la plus éloignée (DST-MAX) est contenu dans le premier desdits champs de contrôle.

8. Procédé selon les revendications 2 ou 3, caractérisé en ce que, pour l'attribution de labels de noeud en ordre ascendant auxdits noeuds, il est envoyé une commande de label contenant un numéro de noeud (NOD-NUM) qui est initialement zéro; en ce que chaque noeud recevant la commande de label augmente le numéro de noeud (NOD-NUM) d'une unité et, ensuite, emmagasine la nouvelle valeur du numéro de noeud comme son propre label de noeud (NOD-LBL) et transmette la commande de label au noeud suivant.

9. Appareil pour permettre un usage multiple de tranches de temps dans un système de communication comprenant un support de transmission unidirectionnel (11, figure 1); plusieurs noeuds (19-1 ... 19-N) qui lui sont connectés, et un moyen de tête de ligne (15) pour engendrer des tranches de temps de transmission et des informations de contrôle passant sur ledit support de transmission; un bloc de commande étant passé à chaque cycle d'une pluralité de cycles opératoires numérotés, comprenant un compte de requêtes (REQ-LEN) que chaque noeud peut modifier par un nombre de tranches de temps requises (ORD-LEN); chaque noeud utilisant après le départ du cycle opératoire respectif le nombre requis de tranches de temps libres; et chaque noeud étant identifié par un label (NOD-LBL) indiquant sa position, ledit appareil comprenant:

dans ledit moyen de tête de ligne:
- un moyen pour engendrer des blocs de commande (figure 6, A, B, C) comprenant, en plus d'un numéro de cycle (CYC-NUM) et d'un champ pour ledit compte de requêtes (REQ-LEN), d'autres champs pour respectivement un label de noeud de destination la plus éloignée (DST-MAX) et pour

un maximum requis (REQ-MAX); et

dans chacun desdits noeuds,

- un moyen (51, figure 10) pour emmagasiner un label de noeud local (NOD-LBL);
- un moyen (39) pour emmagasiner le label (ORD-DST) d'un noeud de destination sélectionnée sur lequel doivent être transmises des données locales;
- un moyen (57) pour comparer le label de noeud de destination la plus éloignée dans un bloc de commande reçu avec le label de noeud local;
- des moyens (33, 35, 61) pour emmagasiner le numéro de cycle avec l'indicateur de réutilisation (REU-FLG), si le label de destination la plus éloignée est inférieur ou égal au label de noeud local, et des moyens (31, 47, 73, 75) pour insérer le label du noeud de destination sélectionnée dans le champ du label de noeud de destination la plus éloignée (DST-MAX) du bloc de commande; et
- des moyens (31, 95, 97, 99, 101) pour rendre disponibles, après le départ d'un cycle opératoire respectif pour lequel le noeud a emmagasiné un indicateur de réutilisation, toutes les tranches de temps de ce cycle opératoire respectif à utiliser par le noeud respectif ou par d'autres noeuds plus en aval.

10. Appareil selon la revendication 9, caractérisé en ce que chaque noeud comprend en outre:

- un moyen (91) pour comparer le maximum requis (REQ-MAX) dans un bloc de commande reçu avec le compte de requêtes en cours (REQ-LEN); et
- des moyens (31, 85, 93) pour remplacer le maximum requis par le compte de requêtes en cours si ce dernier est supérieur.

11. Appareil selon la revendication 9, caractérisé en ce que chaque noeud comprend en outre:

- un moyen (45) pour emmagasiner un nombre requis de tranches (ORD-LEN);
- des moyens (45, 61, 83, 85, 87) pour remplacer le compte de requêtes en cours (REQ-LEN) dans un bloc de commande reçu par le nombre requis de tranches (ORD-LEN) si le label de noeud de destination la plus éloignée (DST-MAX) est inférieur ou égal au label de noeud local (NOD-LBL), mais pour ajouter le nombre requis de tranches au compte requis en cours si le label de noeud de destination la plus éloignée est supérieur au label de noeud local.

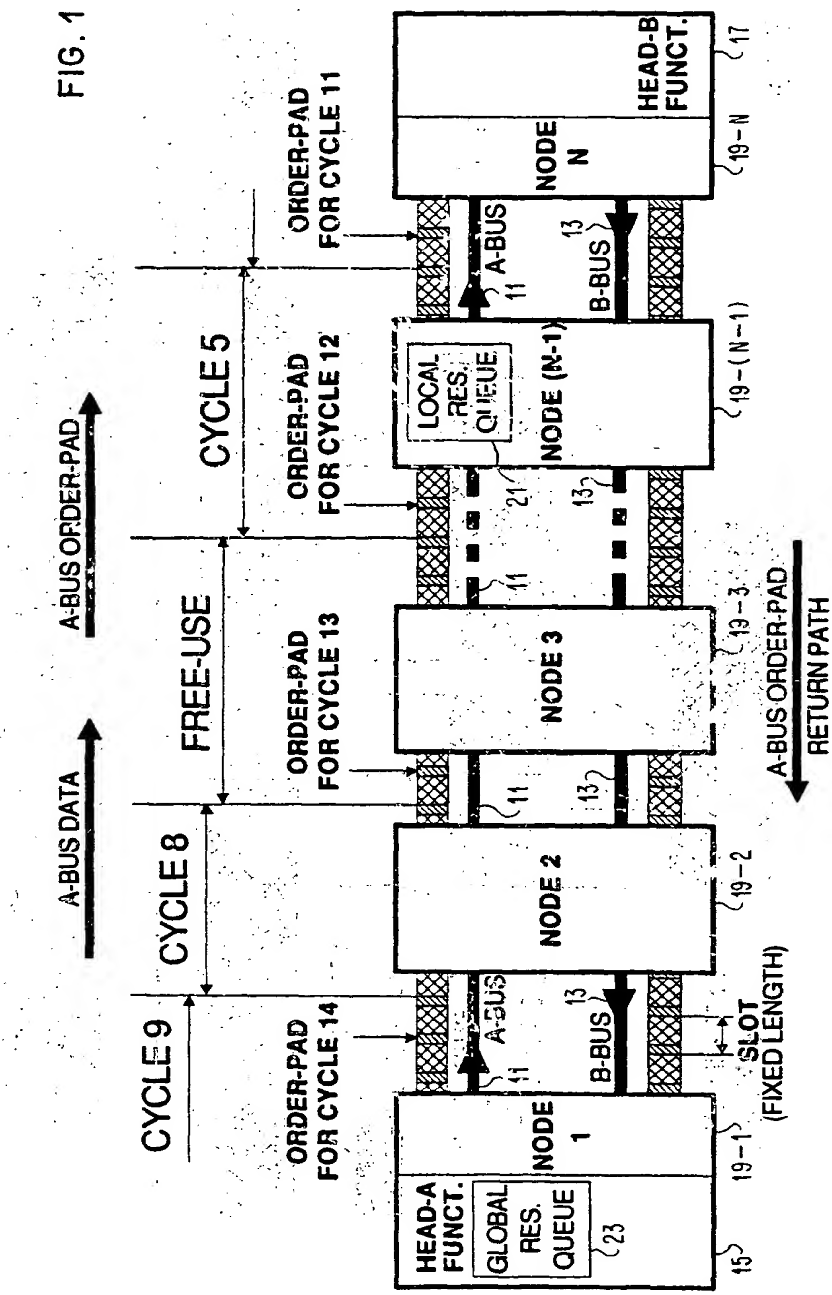
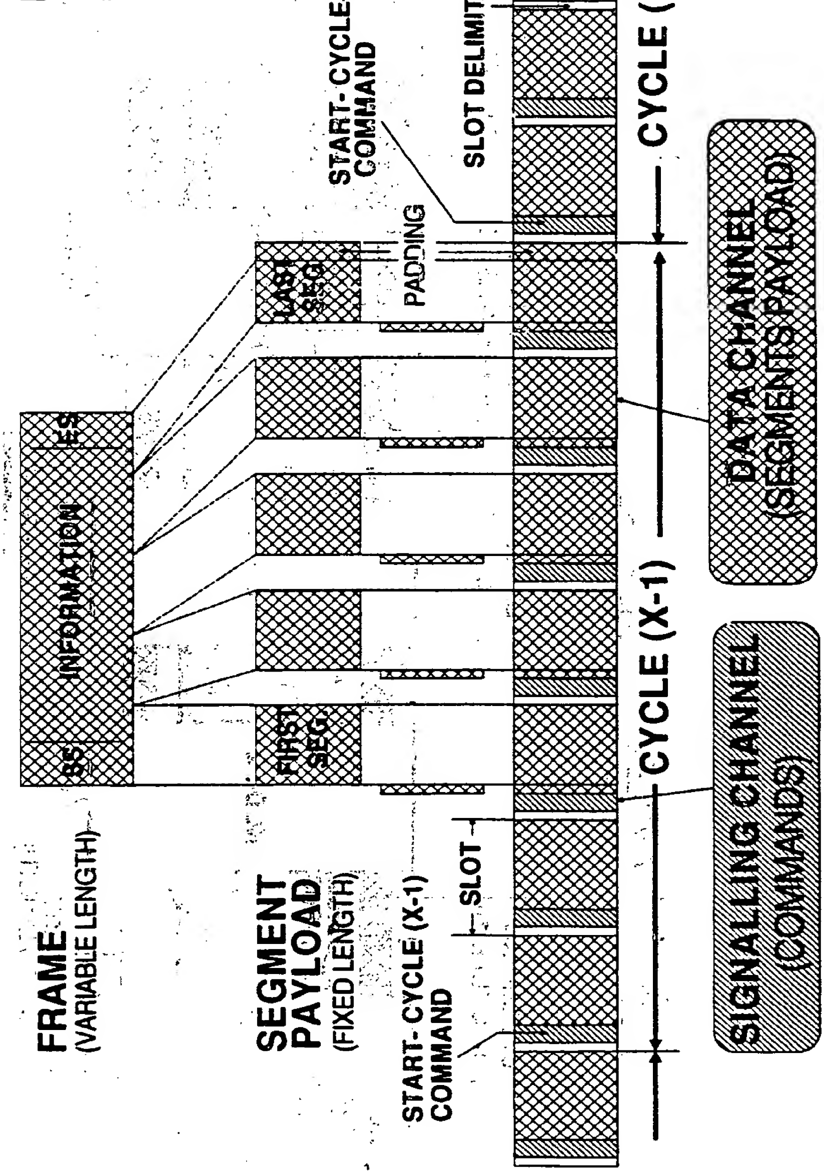

A-BUS DATA
A-BUS ORDER-PAD
CYCLE 9
CYCLE 8
FREE-USE
CYCLE 5
ORDER-PAD FOR CYCLE 14
ORDER-PAD FOR CYCLE 13
ORDER-PAD FOR CYCLE 12
ORDER-PAD FOR CYCLE 11
HEAD-A FUNCT.
GLOBAL RES. QUEUE
23
15
NODE 1
19-1
A-BUS
B-BUS
11
13
SLOT (FIXED LENGTH)
NODE 2
19-2
NODE 3
19-3
A-BUS ORDER-PAD RETURN PATH
21
LOCAL RES. QUEUE
NODE (N-1)
19-(N-1)
NODE N
19-N
HEAD-B FUNCT.
17

FIG. 1

FIG. 2


FRAME
(VARIABLE LENGTH)
SS
INFORMATION
ES
SEGMENT
PAYLOAD
(FIXED LENGTH)
FIRST SEG.
LAST SEG.
PADDING
START-CYCLE (X-1)
COMMAND
START-CYCLE (X)
COMMAND
SLOT
SLOT DELIMITER
CYCLE (X-1)
CYCLE (X)
SIGNALLING CHANNEL
(COMMANDS)
DATA CHANNEL
(SEGMENTS PAYLOAD)

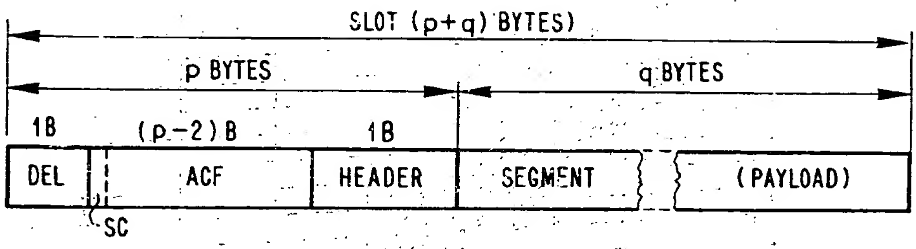


FIG. 3 SLOT STRUCTURE

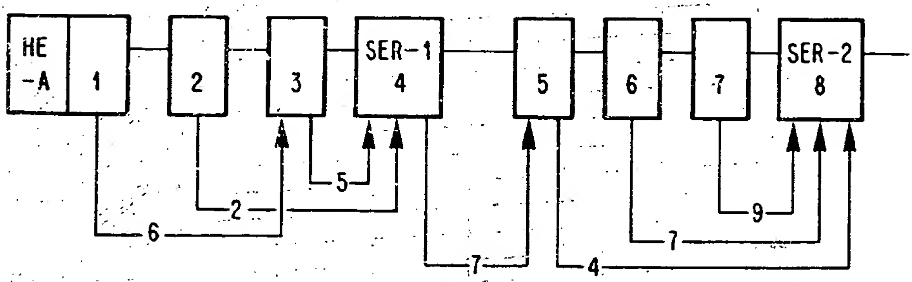
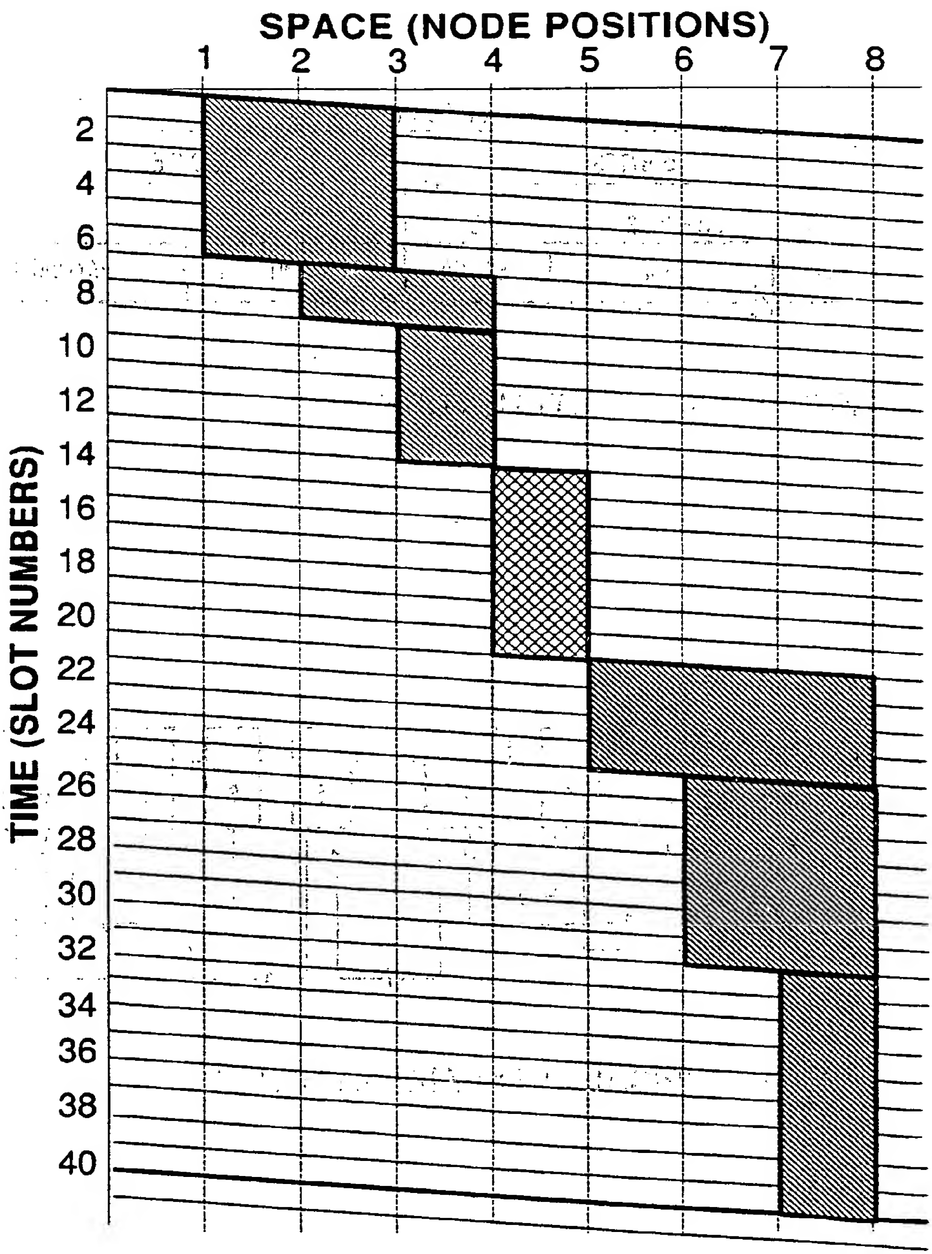


FIG. 4 TYPICAL TRAFFIC SITUATION

FIG. 5


SPACE (NODE POSITIONS)
1 2 3 4 5 6 7 8
TIME (SLOT NUMBERS)
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40

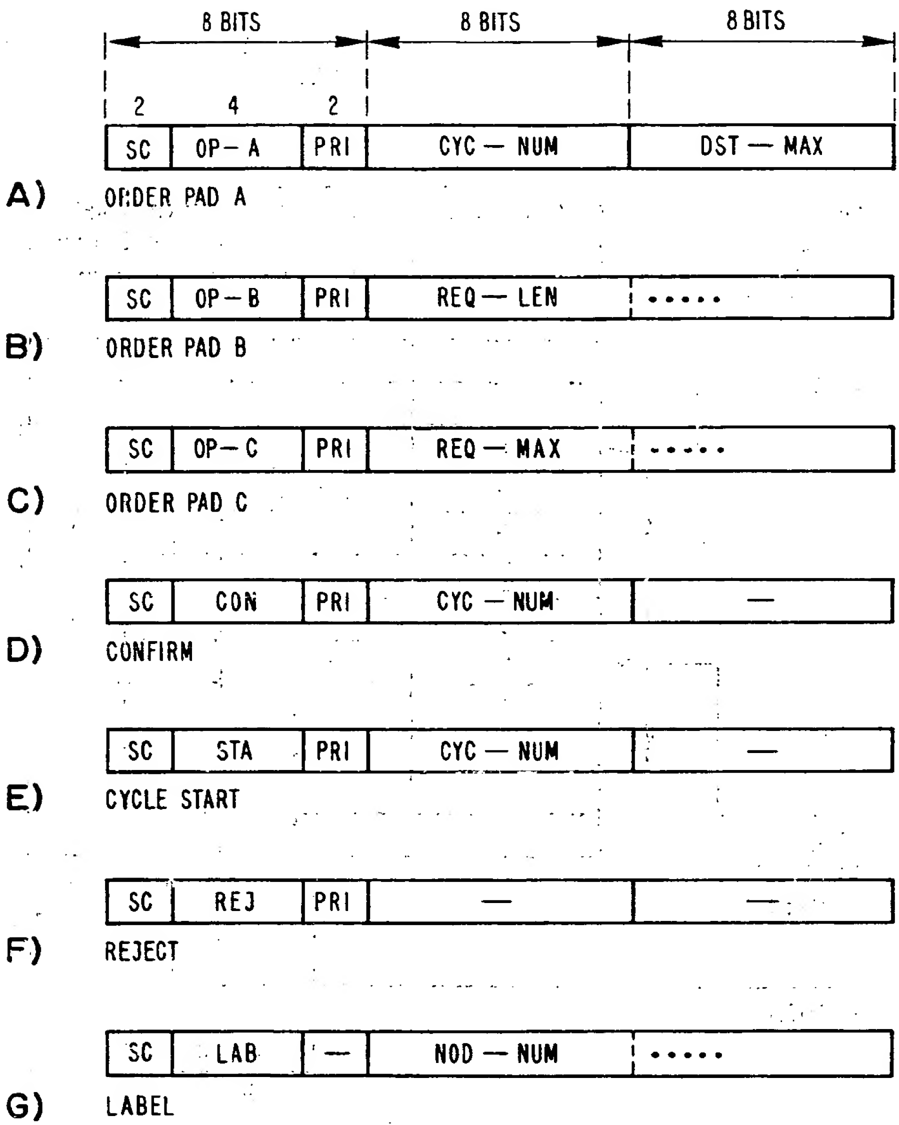


FIG. 6 MAC COMMANDS (ACF CONTENTS)

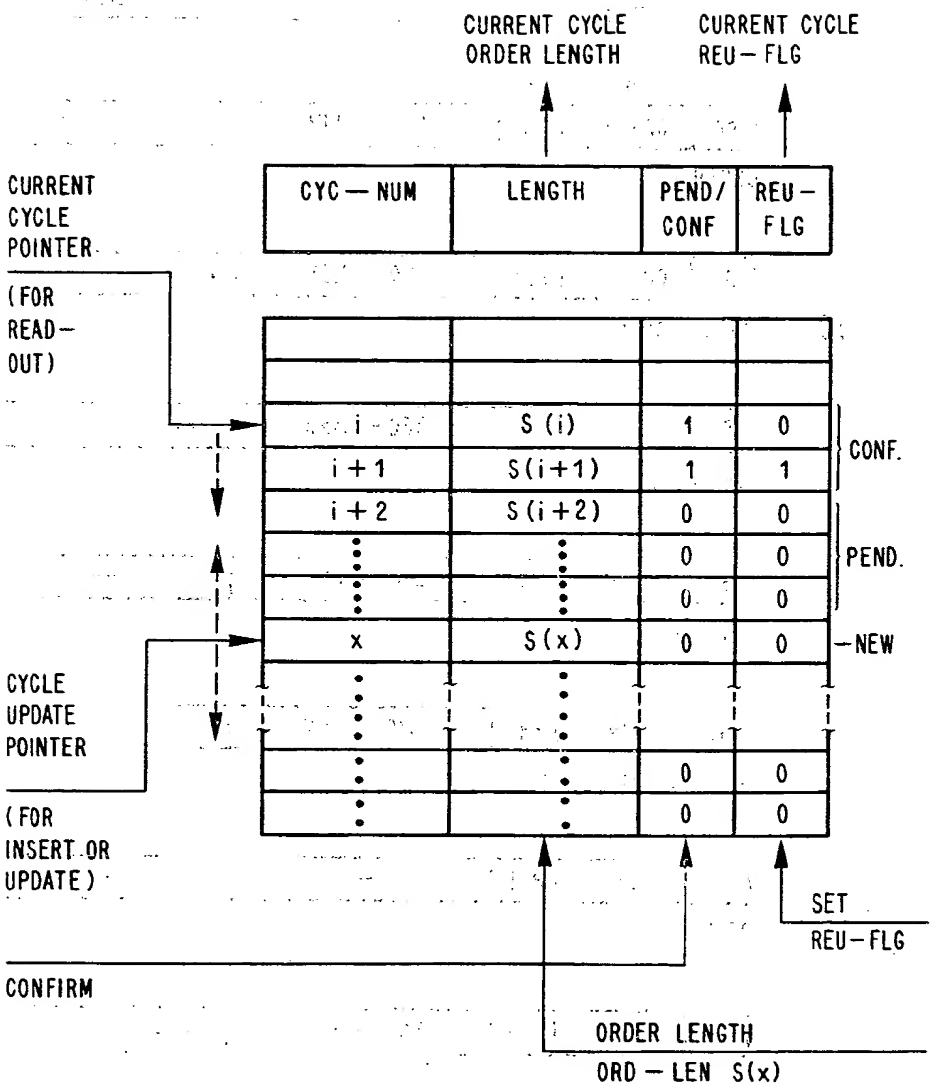


FIG. 7 LOCAL RESERVATION QUEUE

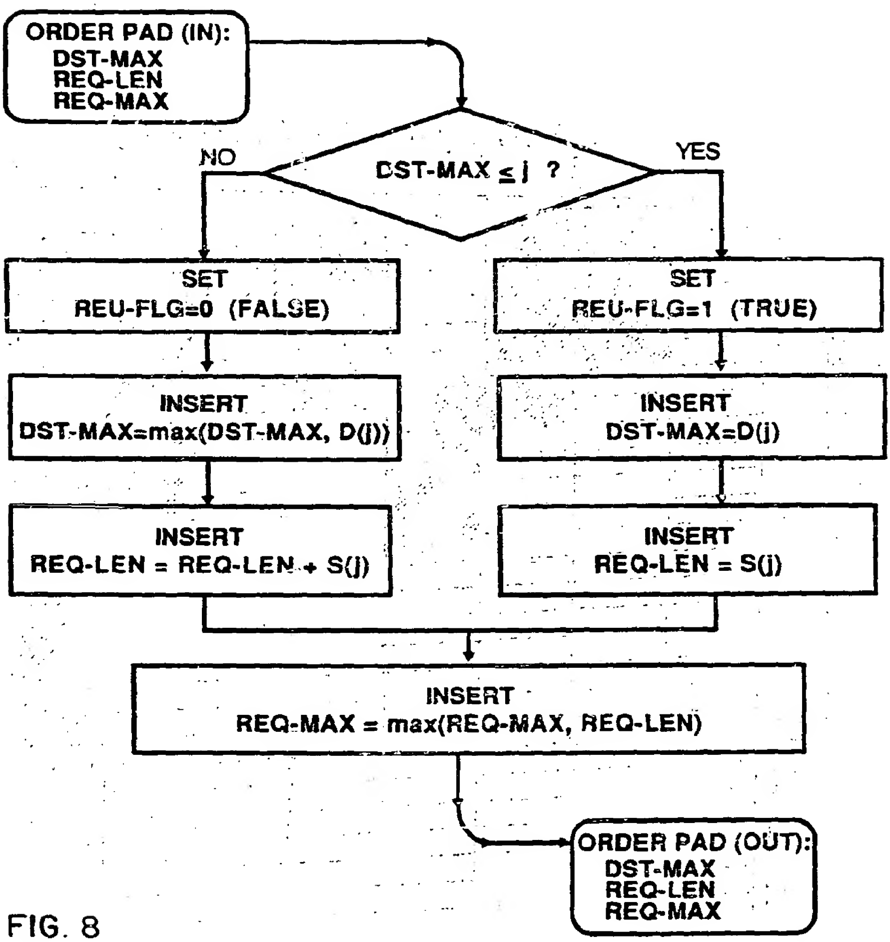
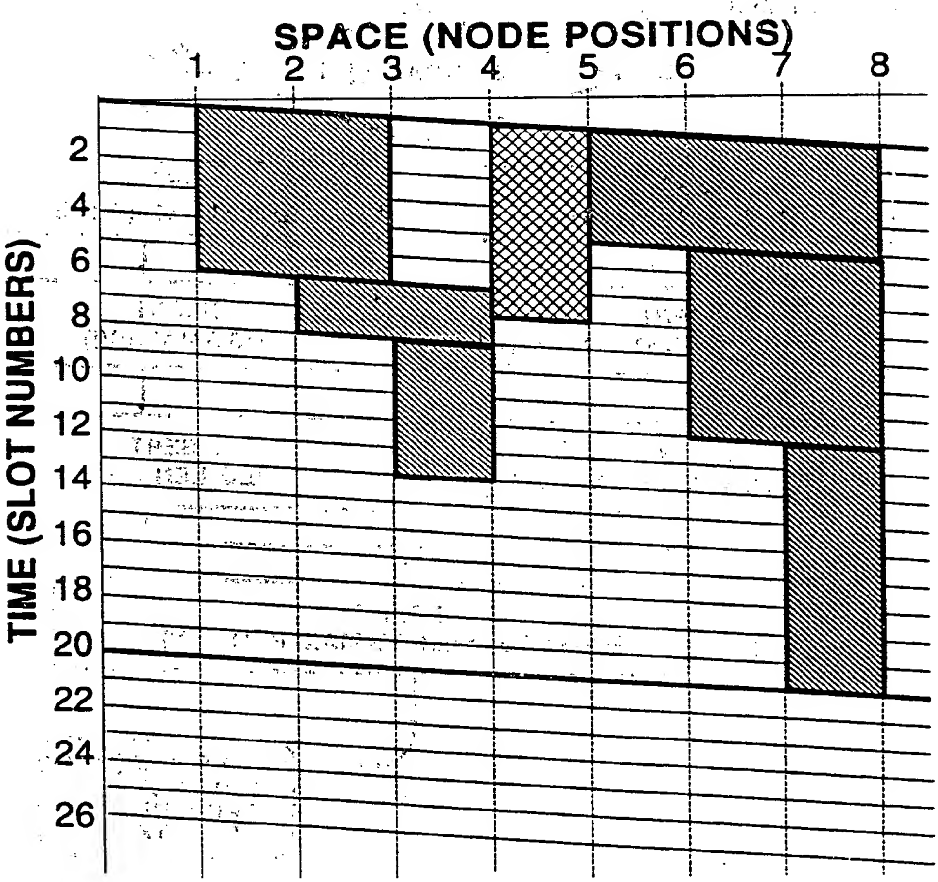

ORDER PAD (IN):
DST-MAX
REQ-LEN
REQ-MAX
DST-MAX ≤ j ?
NO
YES
SET
REU-FLG=0 (FALSE)
SET
REU-FLG=1 (TRUE)
INSERT
DST-MAX=max(DST-MAX, D(j))
INSERT
DST-MAX=D(j)
INSERT
REQ-LEN = REQ-LEN + S(j)
INSERT
REQ-LEN = S(j)
INSERT
REQ-MAX = max(REQ-MAX, REQ-LEN)
ORDER PAD (OUT):
DST-MAX
REQ-LEN
REQ-MAX

FIG. 8

FIG. 9


SPACE (NODE POSITIONS)
1
2
3
4
5
6
7
8
TIME (SLOT NUMBERS)
2
4
6
8
10
12
14
16
18
20
22
24
26

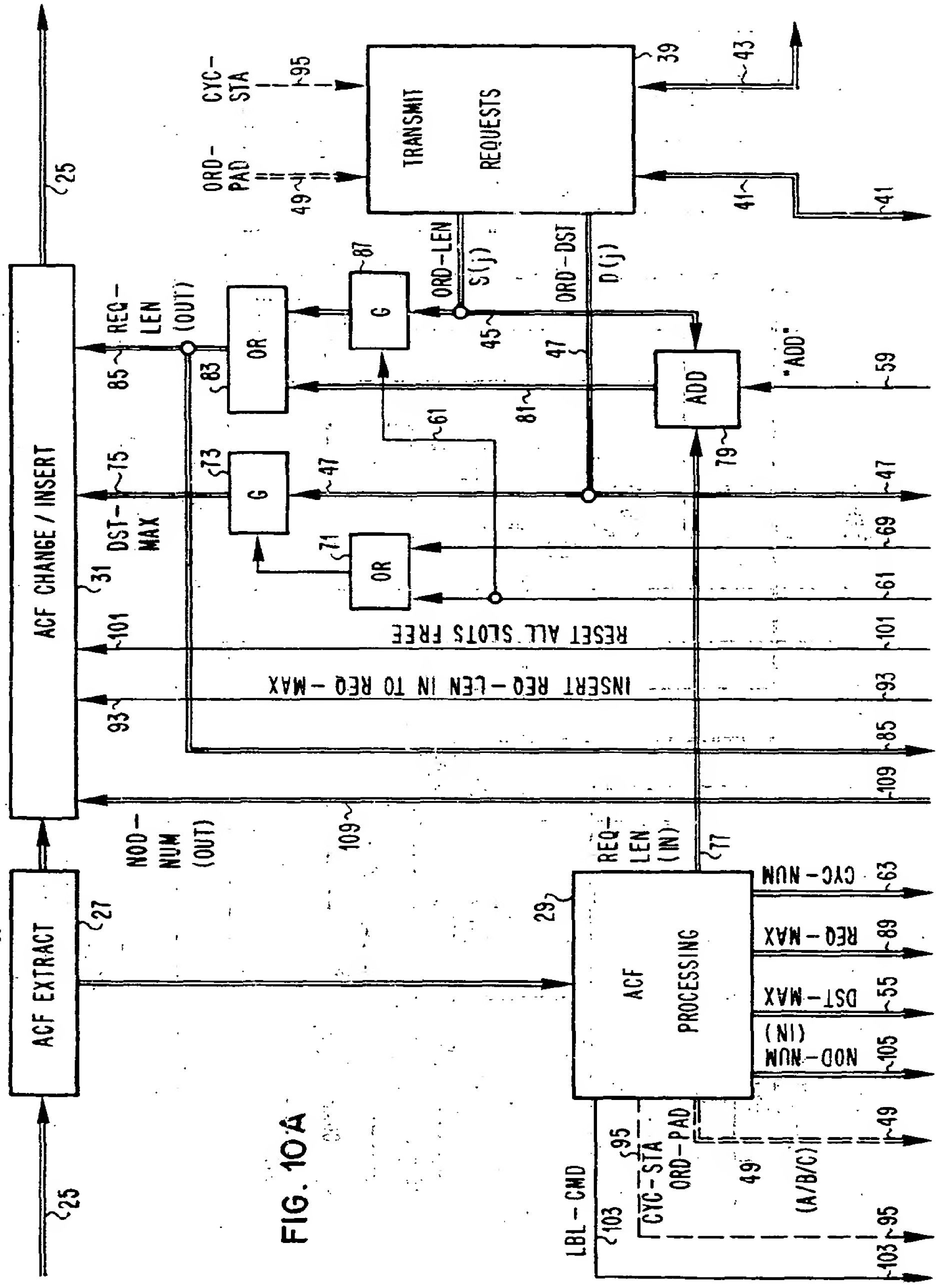

ACF EXTRACT
ACF CHANGE / INSERT
ACF PROCESSING
TRANSMIT REQUESTS
ORD-PAD
CYC-STA
ORD-LEN S(j)
ORD-DST D(j)
REQ-LEN (OUT)
DST-MAX
OR
G
OR
G
ADD
"ADD"
RESET ALL SLOTS FREE
INSERT REQ-LEN IN TO REQ-MAX
NOD-NUM (OUT)
REQ-LEN (IN)
CYC-NUM
REQ-MAX
DST-MAX
NOD-NUM (IN)
LBL-CMD
CYC-STA
ORD-PAD
(A/B/C)

FIG. 10A

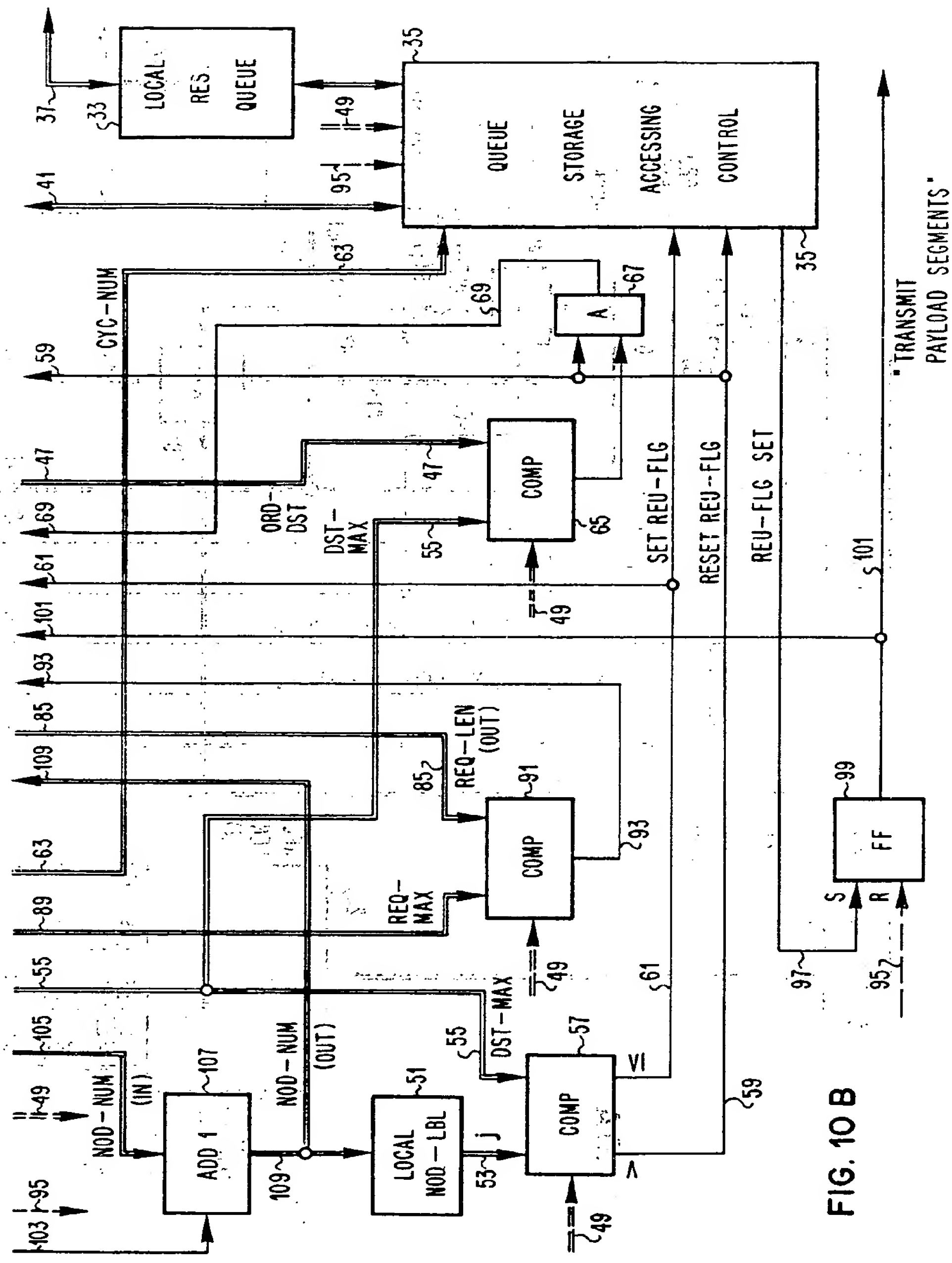

LOCAL RES QUEUE
QUEUE STORAGE ACCESSING CONTROL
CYC-NUM
ORD-DST
DST-MAX
COMP
A
SET REU-FLG
RESET REU-FLG
REU-FLG SET
"TRANSMIT PAYLOAD SEGMENTS"
REQ-LEN (OUT)
REQ-MAX
FF
S
R
NOD-NUM (IN)
ADD 1
NOD-NUM (OUT)
LOCAL NOD-LBL
j
VI
>

FIG. 10 B